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RESEARCH MEMORANDUM

DITCHING TESTS OF A $\frac{1}{18}$-SCALE MODEL OF THE LOCKHEED CONSTELLATION AIRPLANE

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DITCHING TESTS OF A $\frac{1}{18}$-SCALE MODEL OF THE LOCKHEED CONSTELLATION AIRPLANE

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SUMMARY

Tests were made of a $\frac{1}{18}$-scale dynamically similar model of the Lockheed Constellation airplane to investigate its ditching characteristics and proper ditching technique. Scale-strength bottoms were used to reproduce probable damage to the fuselage. The model was landed in calm water at the Langley tank no. 2 monorail. Various landing attitudes, speeds, and fuselage configurations were simulated.

The behavior of the model was determined from visual observations, by recording the longitudinal decelerations, and by taking motion pictures of the ditchings. Data are presented in tabular form, sequence photographs, and time-history deceleration curves.

It was concluded that the airplane should be ditched at a medium nose-high landing attitude with the landing flaps full down. The airplane will probably make a deep run with heavy spray and may even dive slightly. The fuselage will be damaged and leak substantially but in calm water probably will not flood rapidly. Maximum longitudinal decelerations in a calm-water ditching will be about 4g.

INTRODUCTION

Model tests were made to determine the probable ditching characteristics and the proper ditching technique for the Lockheed Constellation airplane. The model was designed so that either a relatively rigid or an approximately scale-strength bottom could be used. The tests were made in calm water at the Langley tank no. 2 monorail. Design information regarding the airplane was furnished by the Lockheed Aircraft Corporation. A three-view drawing of the airplane is shown in figure 1.

APPARATUS AND PROCEDURE

Description of Model

The $\frac{1}{18}$-scale model had a wing span of 6.84 feet, a fuselage length of 5.27 feet, and a gross weight of 14.5 pounds. Photographs of the model are shown in figure 2. The model was constructed principally of balsa wood with spruce at points of concentrated stress. Internal ballast was used to obtain scale weight and moments of inertia.

The landing flaps were installed so that they could be held in the down positions at approximately scale strength. A calibrated string was fastened between a wing bracket and a corresponding flap bracket so that loads on the flap greater than the scale design load would cause the string to break and the entire flap to be torn away. Information obtained from Lockheed Aircraft Corporation indicated that if the flaps failed they would be completely torn from the wing.

The strength of the fuselage below the floor as estimated by the manufacturer is given in figure 3. From this information it was assumed that the wheel doors would be completely torn away in a ditching and that the fuselage below the floor, except the section between the wing beams, would be damaged. Accordingly, the bottom of the model below the floor was made removable and scale-strength replacements for the bottom were developed. One of these scale-strength bottoms installed on the model is shown in figure 4. The scale-strength bottoms were made of balsa ribs and stringers and were covered with thin doped paper. They were designed and tested to fail under a uniformly distributed load of 8 psi (full-scale). A scale-strength bottom in the load-testing apparatus is shown in figure 5. The loading of the test bottom was accomplished by increasing the air pressure inside the test chamber, the pressure being applied to the outside of the test bottom. The pressure required to cause failure was measured by the manometer shown on the right in figure 5.

Test Methods and Equipment

The model was ditched by catapulting it from the carriage on the Langley tank no. 2 monorail so that it was free to glide onto the water. It was launched at scale speed and the desired landing attitude, and the control surfaces were set so that the attitude did not change appreciably in flight. The behavior was determined from visual observation, motion-picture records, and time-history accelerometer records (longitudinal). The accelerometer had a natural frequency of about 17 cycles per second and was damped to about 65 percent of critical damping. The reading accuracy of the instrument was about $\pm\frac{1}{2}g$.

Test Conditions

(All values given refer to the full-scale airplane.)

Weight.- The weight corresponded to a gross weight of 84,500 pounds.

Center of gravity.- The longitudinal location of the center of gravity was 25 percent of the mean aerodynamic chord; the vertical location was 23.04 inches above the thrust line of the inboard engines.

Landing attitude.- Attitude is the angle between the fuselage reference line and the water surface. Three landing attitudes were investigated; 12° (near stall), 9° (intermediate), and 4° (near three-wheel static attitude).

Flaps.- Tests were made with the flaps up, 60 percent down, and full down. When down the flaps were attached at a scale strength corresponding to an ultimate loading on the flaps of 2 psi.

Landing speed.- The landing speeds are listed in table I. They were computed using lift curves and the previously chosen values of weight, attitude, and flap setting.

Landing gear.- All tests simulate ditchings with the landing gear retracted.

Conditions of damage.- The following fuselage configurations were investigated:

(a) No damage.

(b) Simulated failure of the wheel doors and a scale-strength bottom from stations 333 to 508 and stations 622 to 1060.

RESULTS AND DISCUSSION

A summary of the results of the investigation is presented in table I. The symbols used in the table are defined as follows:

b deep run - a run in which the model travels through the water partially submerged exhibiting a tendency to dive although the attitude remains near level

d slight dive - a dive in which the angle between the water surface and the fuselage reference lines is about 20° and the wings are partially submerged h smooth run - a run in which there is no apparent oscillation about any axis and during which the model settles into the water as the forward velocity decreases.

p porpoising - an undulating motion about the transverse axis in which some part of the model is always in contact with the water

s skipping - an undulating motion about the transverse axis in which the model clears the water completely

u trimmed up - the attitude increases immediately after contact with the water

Typical damage sustained by the scale-strength bottoms is shown in figures 6 and 7. Figures 8 and 9 present longitudinal deceleration curves as influenced by flap setting and landing attitude. Sequence photographs of ditchings at three different attitudes are shown in figure 10.

Effect of Damage

When the model was tested with a scale-strength bottom, some damage always occurred. In general, bottom damage caused the landing runs to be shorter and the decelerations to be higher than for similar test conditions without damage. In some cases smooth runs were changed to porpoising runs or deep runs and deep runs were changed to dives when damage occurred. In other cases there was little difference in motion due to damage. (See table I and figs. 6 and 7.) For certain test conditions, the behavior of the model was characterized by two different type runs. When scale-strength bottoms were used, these different type runs were accompanied by different amounts of damage. Figure 6(a) shows the amount of damage that occurred in a porpoising run and figure 6(b) shows the damage that occurred in a deep run, both at the same landing attitude and flap setting. Figures 6 and 7(a) show the damage sustained in 12° landings with various flap settings. The most severe damage occurred when the flaps were full up, probably due to the higher landing speed. The damage sustained in landings at 12°, 9°, and 4° attitudes with flaps full down is shown in figure 7. In each case the damage was slight even though the motions of the model varied from a deep run to a dive.

On the basis of damage sustained by the scale-strength bottoms it can be expected that in a calm-water ditching the fuselage will be damaged and leak substantially but probably will not flood excessively fast. Since the airplane is a low-wing type, the wing should provide enough buoyancy to float the airplane fairly high in the water.

Effect of Flaps

The landing flaps were so located and of such strength that their setting affected the ditching behavior of the model. Generally, smooth runs resulted when the flaps were up and deep runs with occasional slight dives resulted when the flaps were down. When full down, the inboard flaps usually failed after producing a slight nose-down motion. The outboard flaps generally did not fail. The flaps, when 60 percent down, did not fail and produced greater nose-down pitching than did the full-down flaps. Figure 8 gives time histories of decelerations for landings at 12° attitude with the undamaged model with flaps up, 60 percent down, and full down.

The use of flaps caused the ditching motions to be somewhat worse than those obtained with flaps up. However, the behavior with flaps down is not prohibitive. Full flaps make possible a substantial decrease in forward speed and thus lessen the possibility of excessive damage (see figs. 6(b) and 7(a)). Consequently, it is probably best that the flaps be full down in a ditching.

Effect of Landing Attitude

The effect of landing attitude was most apparent in the investigation of the undamaged model. The 4° attitude produced the most severe ditchings (the decelerations were highest and the motions were most violent) and the 12° attitude produced the least severe ditching (see table I). There was little difference in the ditchings at 12° and 9° except that the decelerations were lower in a 12° landing. The landing attitude did not have as much effect on the model when ditched with a scale-strength bottom. With flaps full down, the 12° attitude resulted in the smoothest run, the 9° attitude resulted in the lowest decelerations, and the 4° attitude resulted in the most severe run (see table I and figs. 9 and 10). The landings were usually accompanied by heavy spray (see fig. 10).

Since the 4° attitude tends to be the most severe and as there is little to choose from between the 9° and 12° attitudes, a medium nose-high attitude is recommended for ditching. In a calm-water landing the airplane will probably make a deep run with a maximum deceleration of about 4g.

CONCLUSIONS

From the results of the model tests the following conclusions are made:

1. The Lockheed Constellation should be ditched at a medium nose-high attitude. The landing flaps should be full down.

2. The airplane will probably make a deep run with heavy spray and may even dive slightly.

3. The fuselage will be damaged and leak substantially but in calm water it probably will not flood rapidly.

4. Maximum longitudinal decelerations in a calm-water ditching will be about 4g.

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TABLE I.- SUMMARY OF RESULTS OF DITCHING TESTS IN CALM WATER OF A $\frac{1}{18}$-SCALE

DYNAMIC MODEL OF THE LOCKHEED CONSTELLATION AIRPLANE

[Gross weight 83,000 pounds; all values are full-scale]

Landing attitude (deg)		12									9									4								
Landing speed (mph)		118			97			85			132			104			91			171			122			105		
Configuration	Flap setting / Behavior (a)	Max	Run	Mo	Max	Run	Mo	Max	Run	Mo	Max	Run	Mo	Max	Run	Mo	Max	Run	Mo	Max	Run	Mo	Max	Run	Mo	Max	Run	Mo
Undamaged	Up	1	620	h							2	610	uh							6	900	sh						
	60 percent				2	340	p b							4	380 180	h b							6	140	d			
	Down							3	270	b							4	380	b							4	270	d
Scale-strength bottom installed and wheel doors removed	Up	5	340	p b							4	380	h															
	60 percent				4	220	d																					
	Down							4	220	h b							3	330	b d							4	220	b d

[a]Max maximum longitudinal decelerations, given in multiples of the acceleration of gravity.
Run length of landing run, given in feet.
Mo motions of the model, denoted by the following symbols:
- b ran deeply
- d dived slightly
- h ran smoothly
- p porpoised
- s skipped
- u trimmed up

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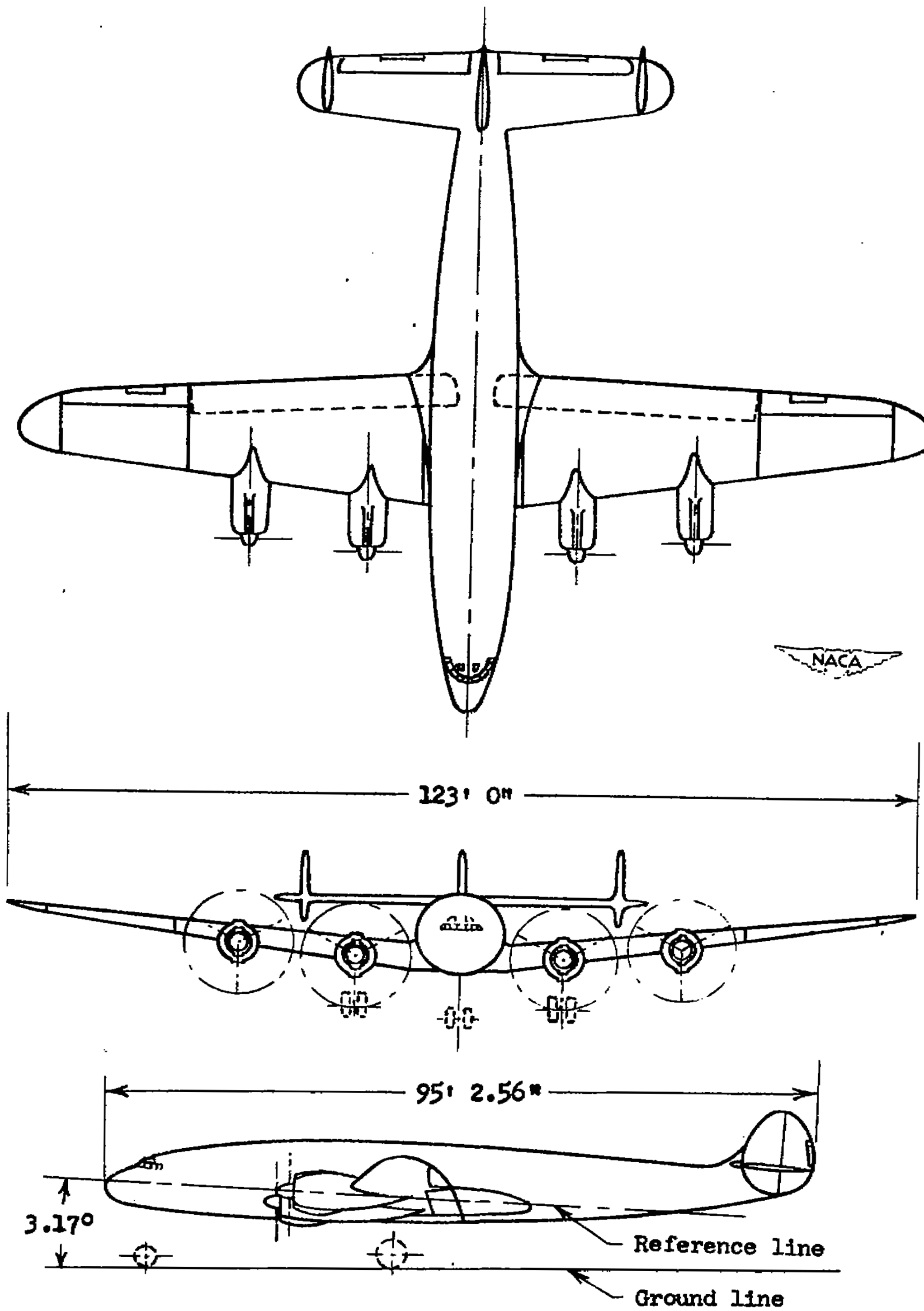
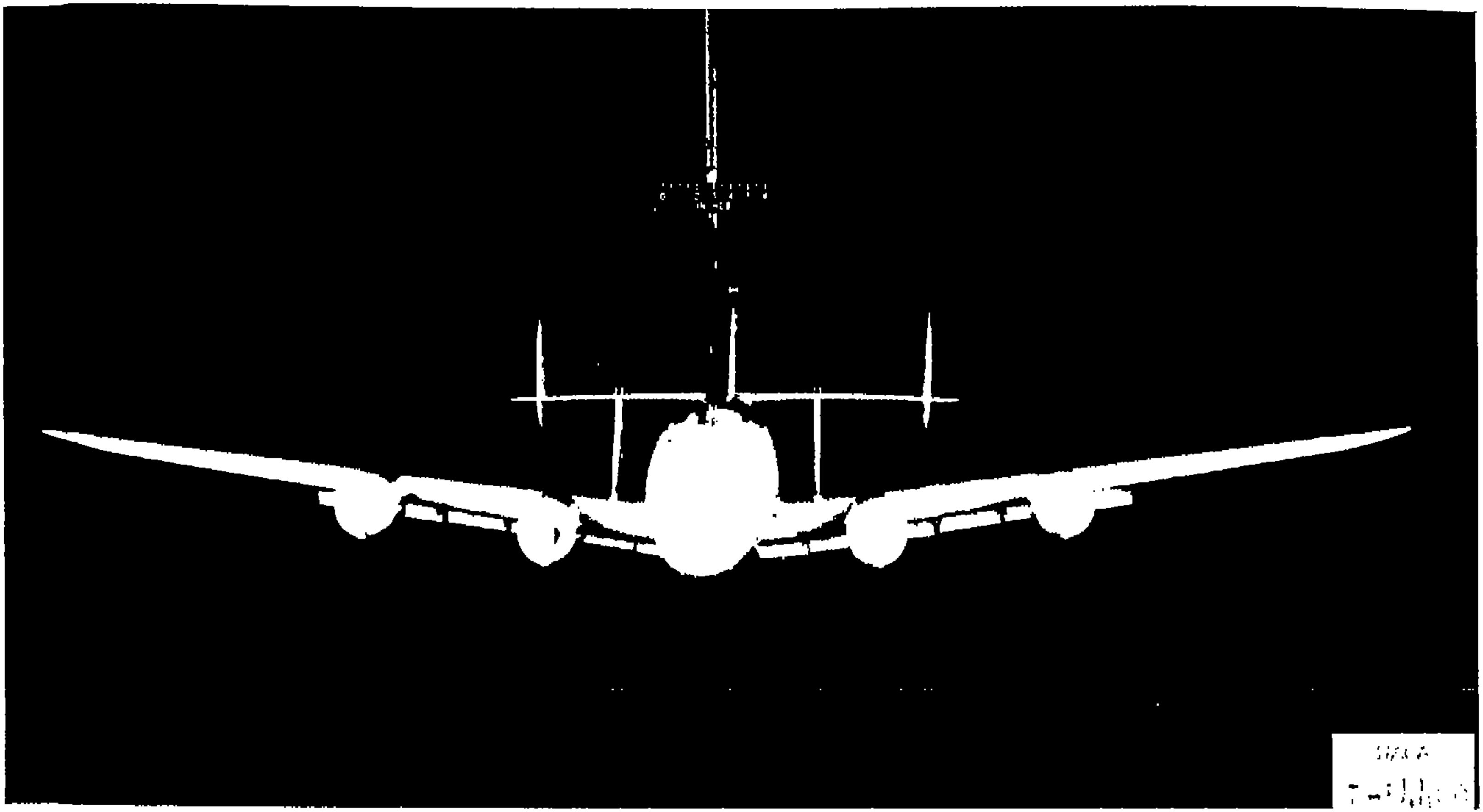
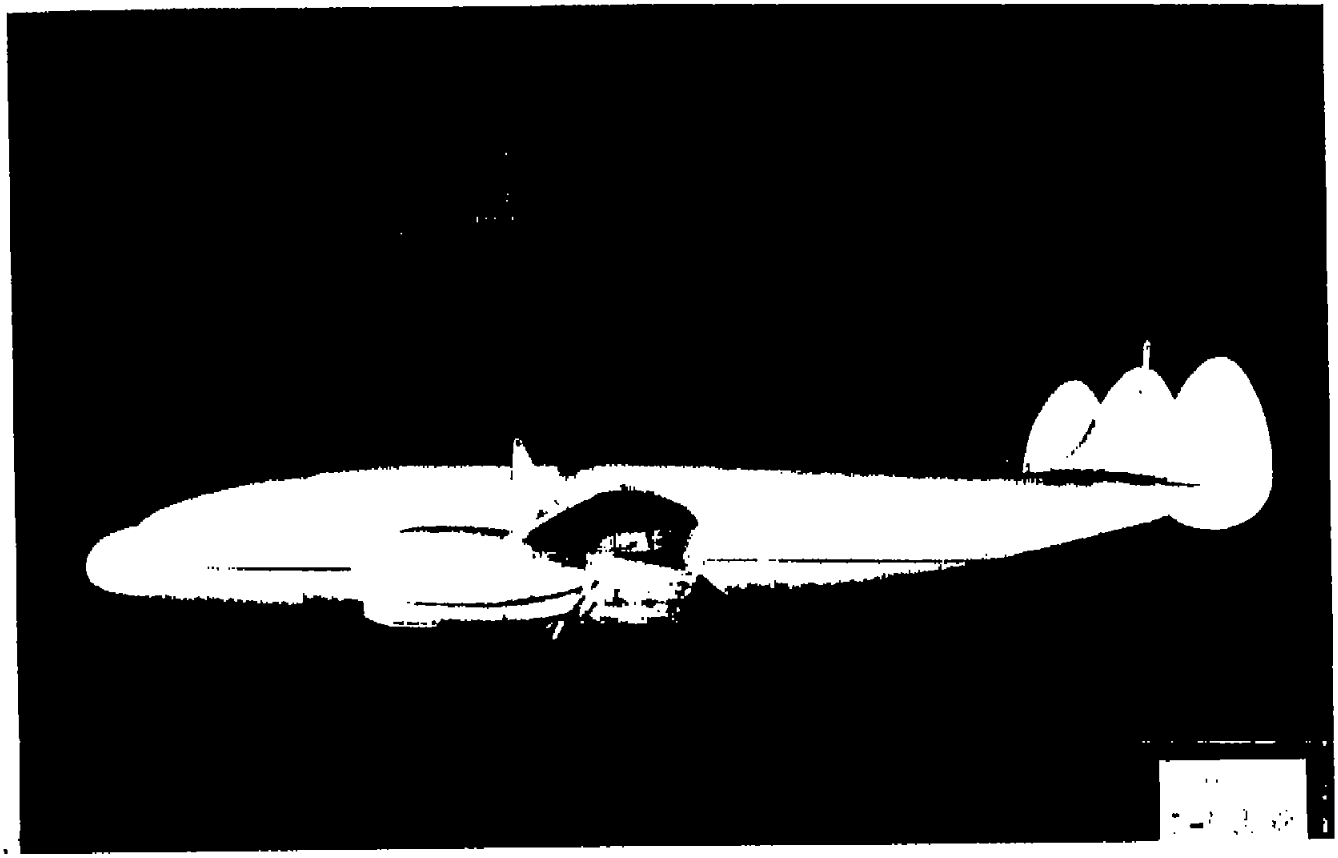


Figure 1.- Three-view drawing of the Lockheed Constellation airplane.



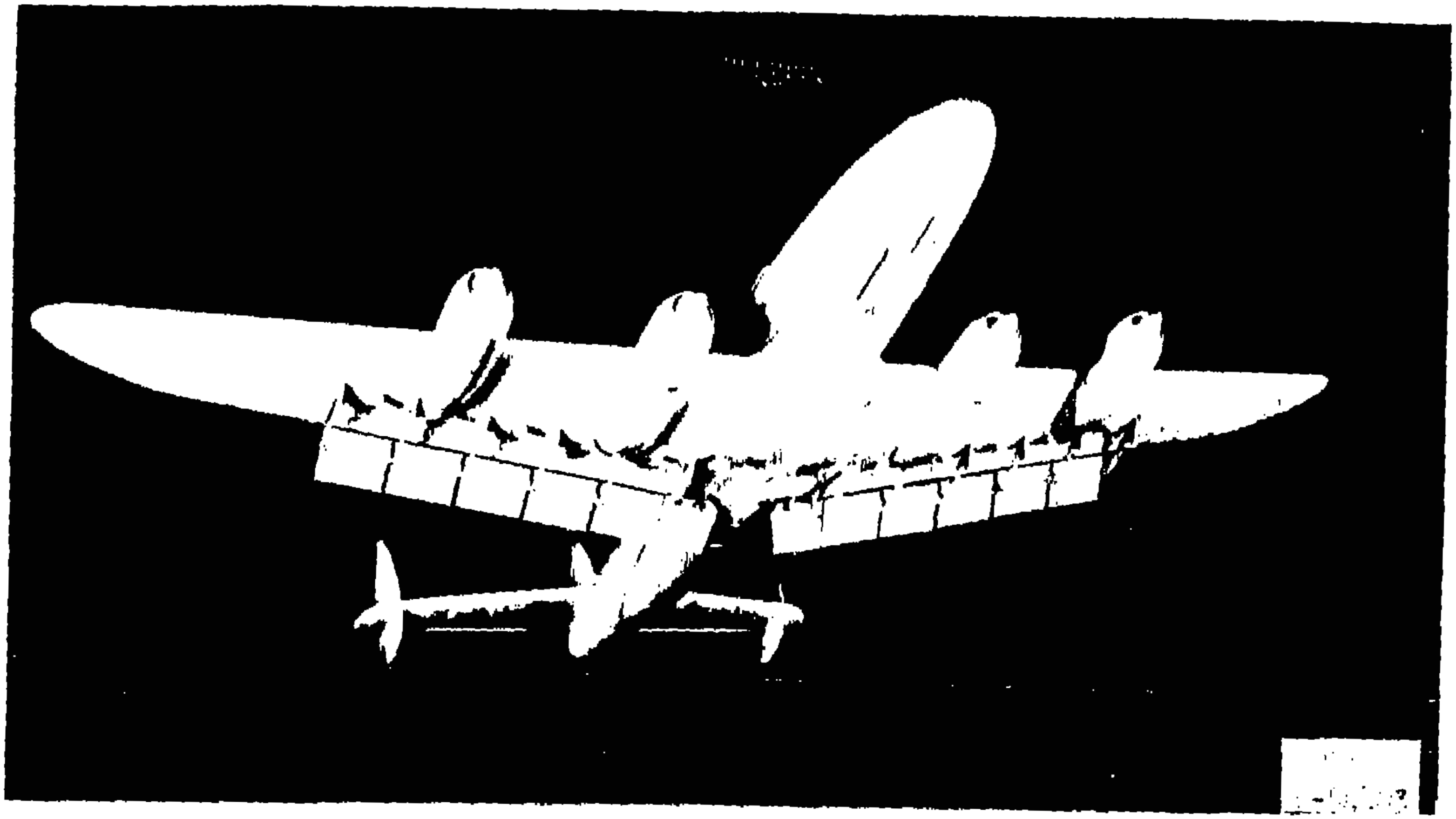
(a) Front view.

Figure 2.- Model of the Constellation.



(b) Side view.

Figure 2.- Continued.



(c) Three-quarter bottom view.

Figure 2.- Concluded.

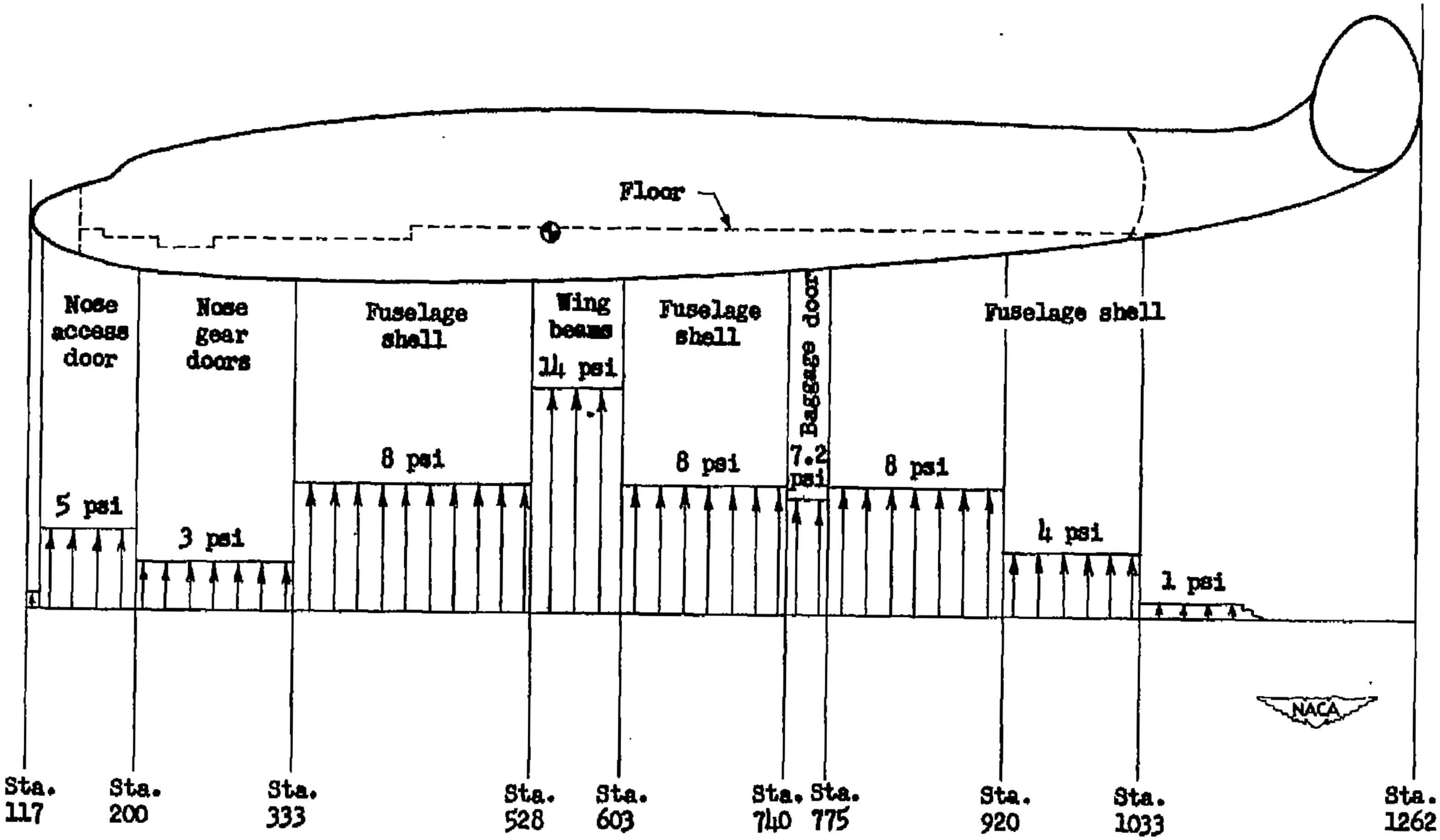


Figure 3.- Estimated strength of fuselage below floor.

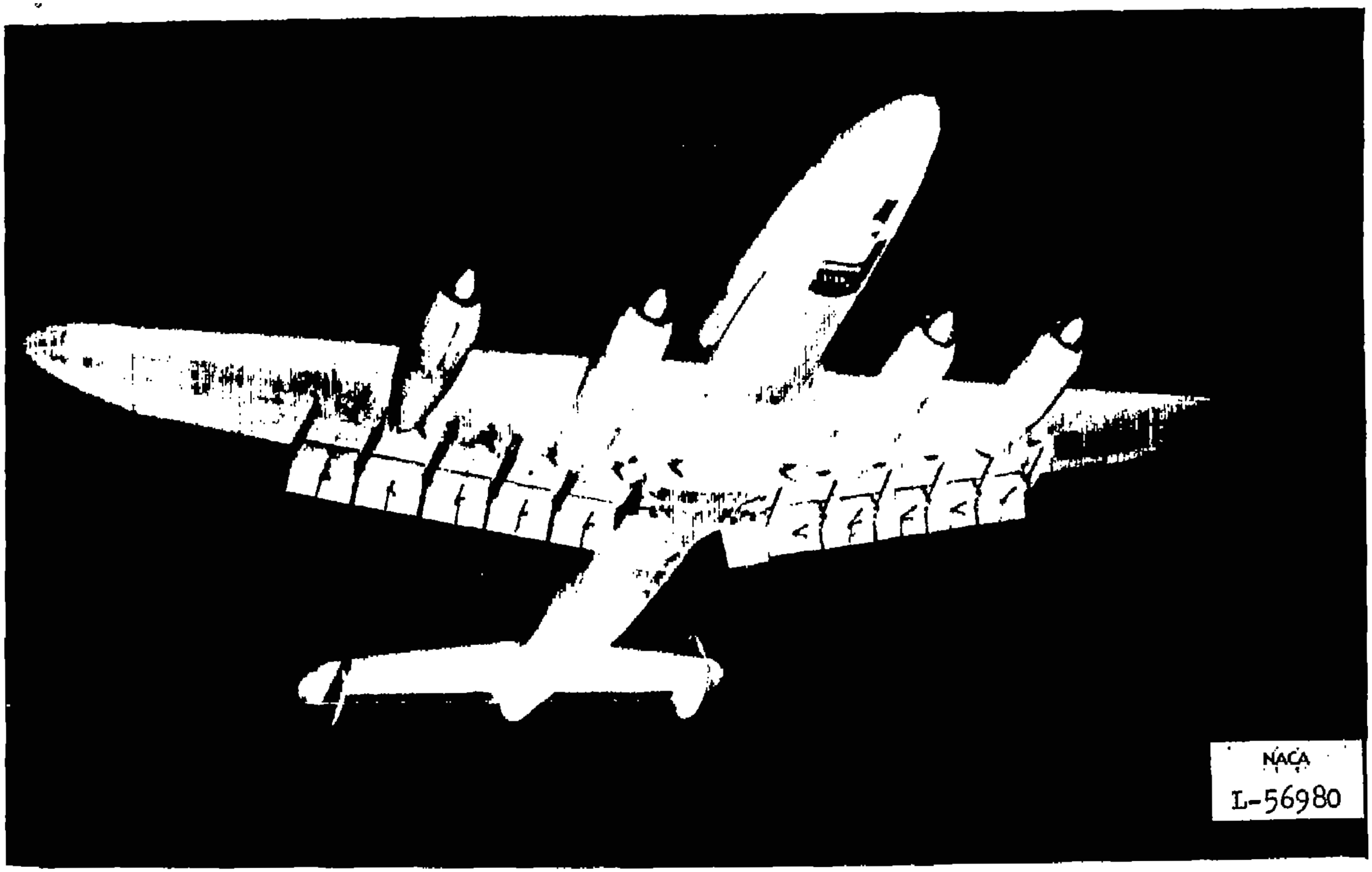


Figure 4.- Model with scale-strength bottom installed.

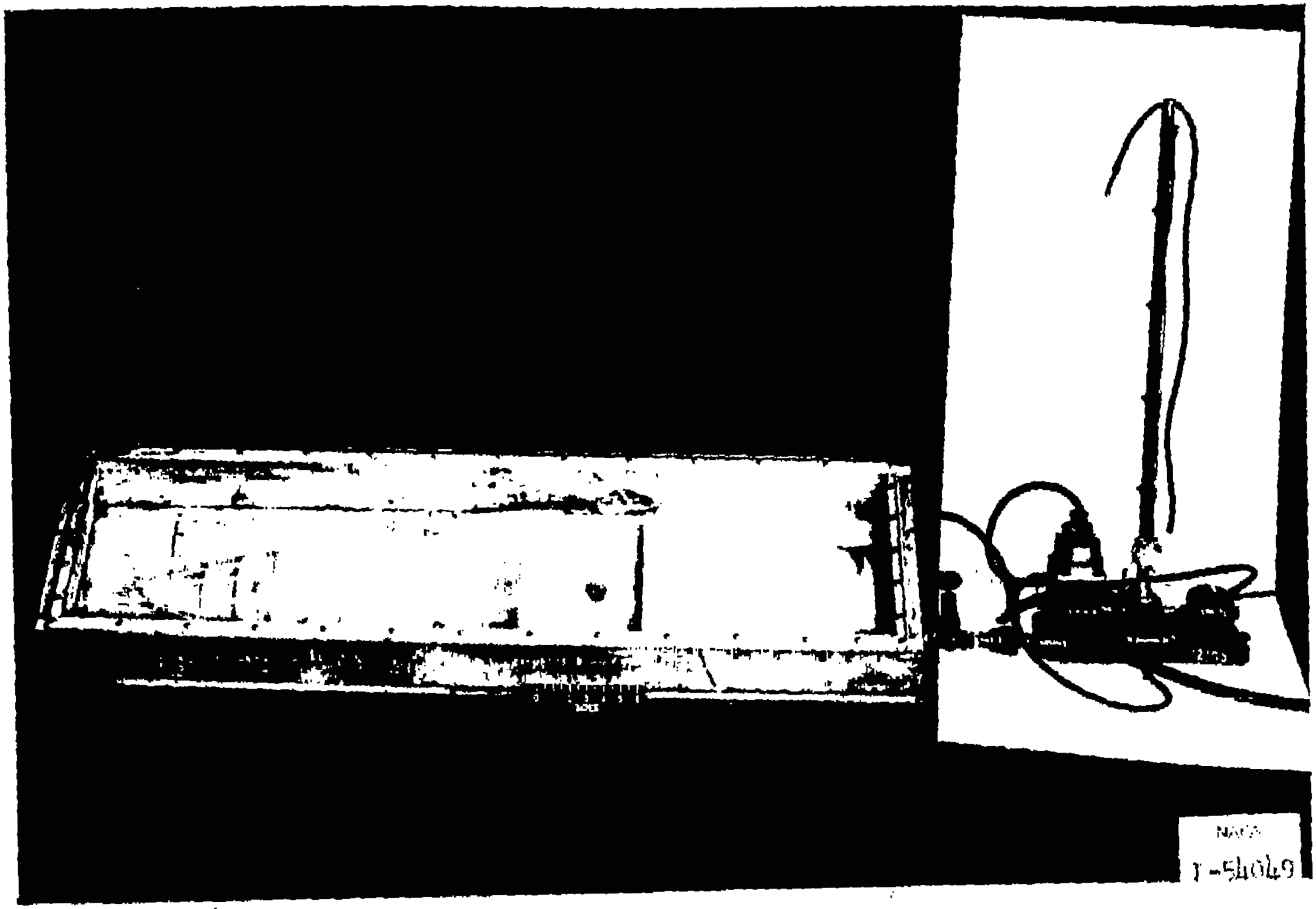
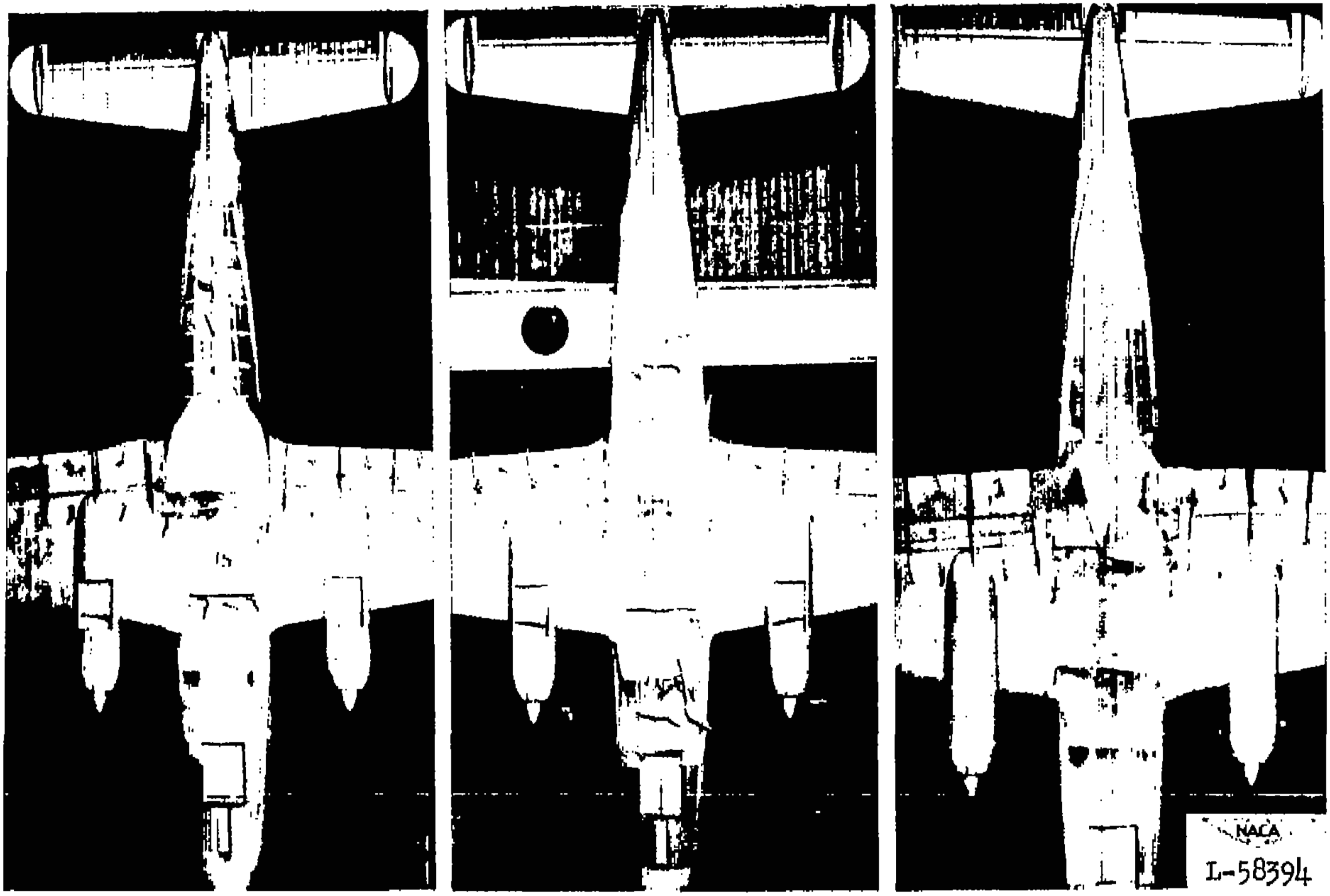


Figure 5.- Scale-strength bottom in testing apparatus.

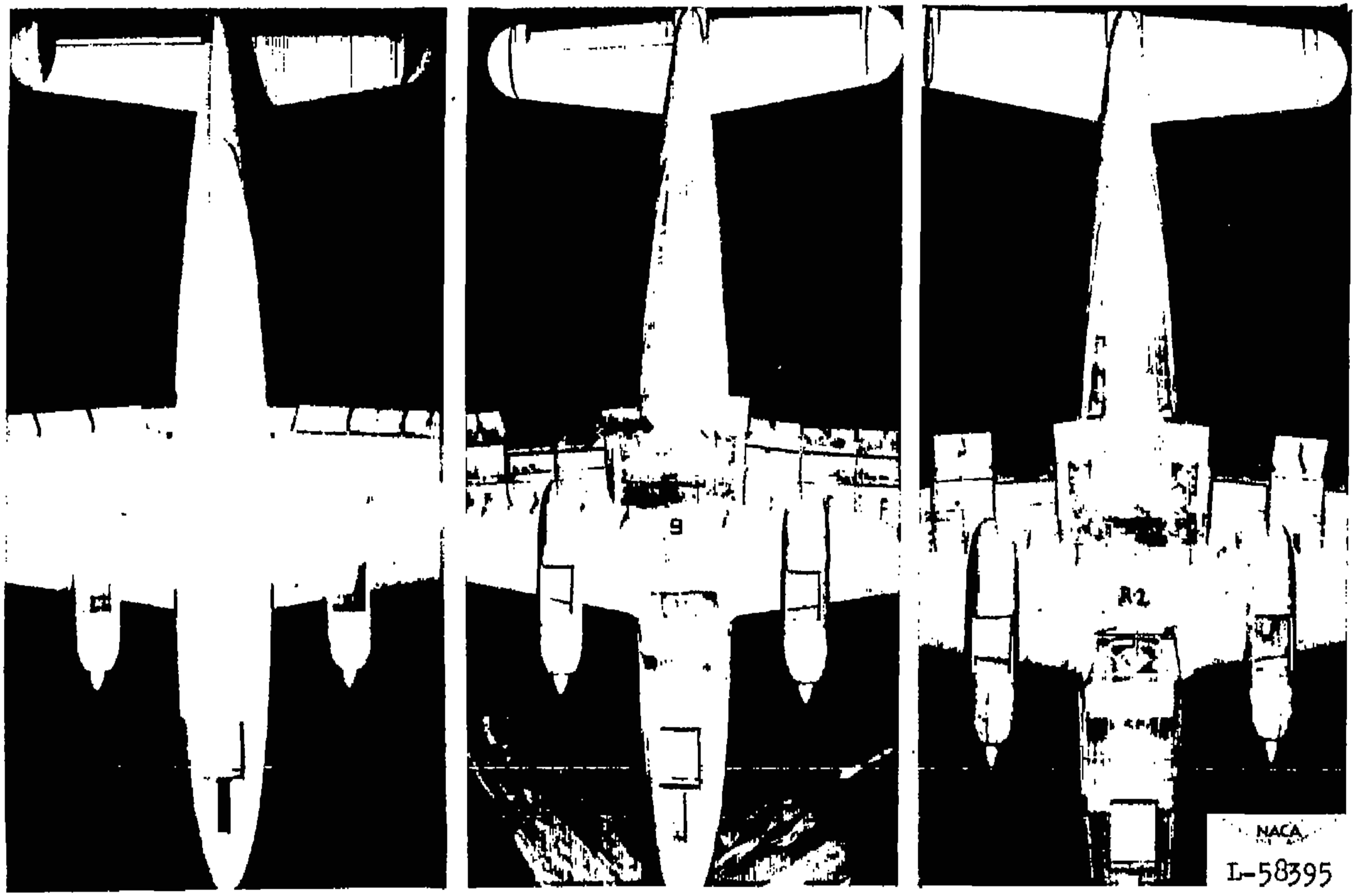


(a) Flaps up; porpoised.

(b) Flaps up; ran deeply.

(c) Flaps down 60 percent; dived slightly.

Figure 6.- Damage sustained by scale-strength bottom at 12° landing attitude with various flap settings.

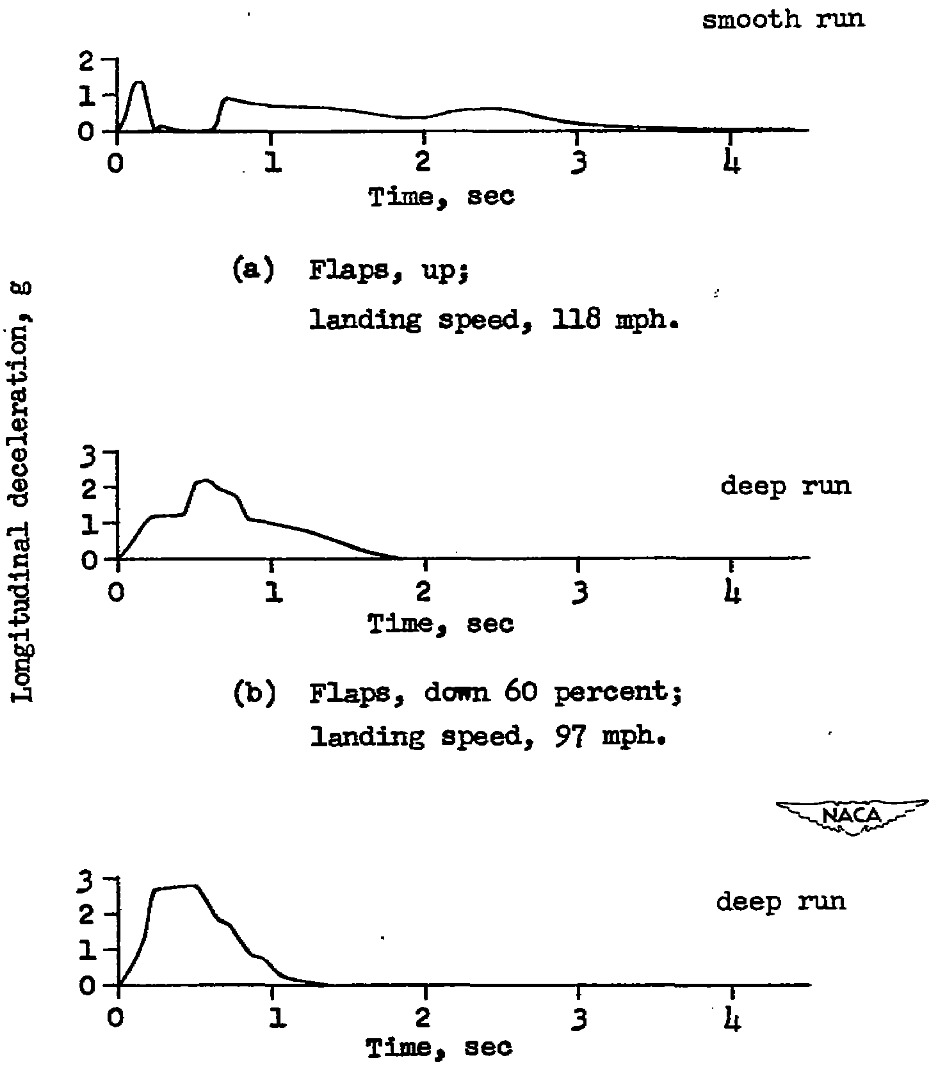


(a) Landing attitude, 12°; ran deeply.

(b) Landing attitude, 9°; ran deeply.

(c) Landing attitude, 4°; ran deeply.

Figure 7.- Damage sustained by scale-strength bottom at various landing attitudes with flaps full down.



(a) Flaps, up;
landing speed, 118 mph.

(b) Flaps, down 60 percent;
landing speed, 97 mph.

(c) Flaps, full down;
landing speed, 85 mph.

Figure 8.- Longitudinal decelerations at 12° landing attitude with no damage simulated. All values are full scale.

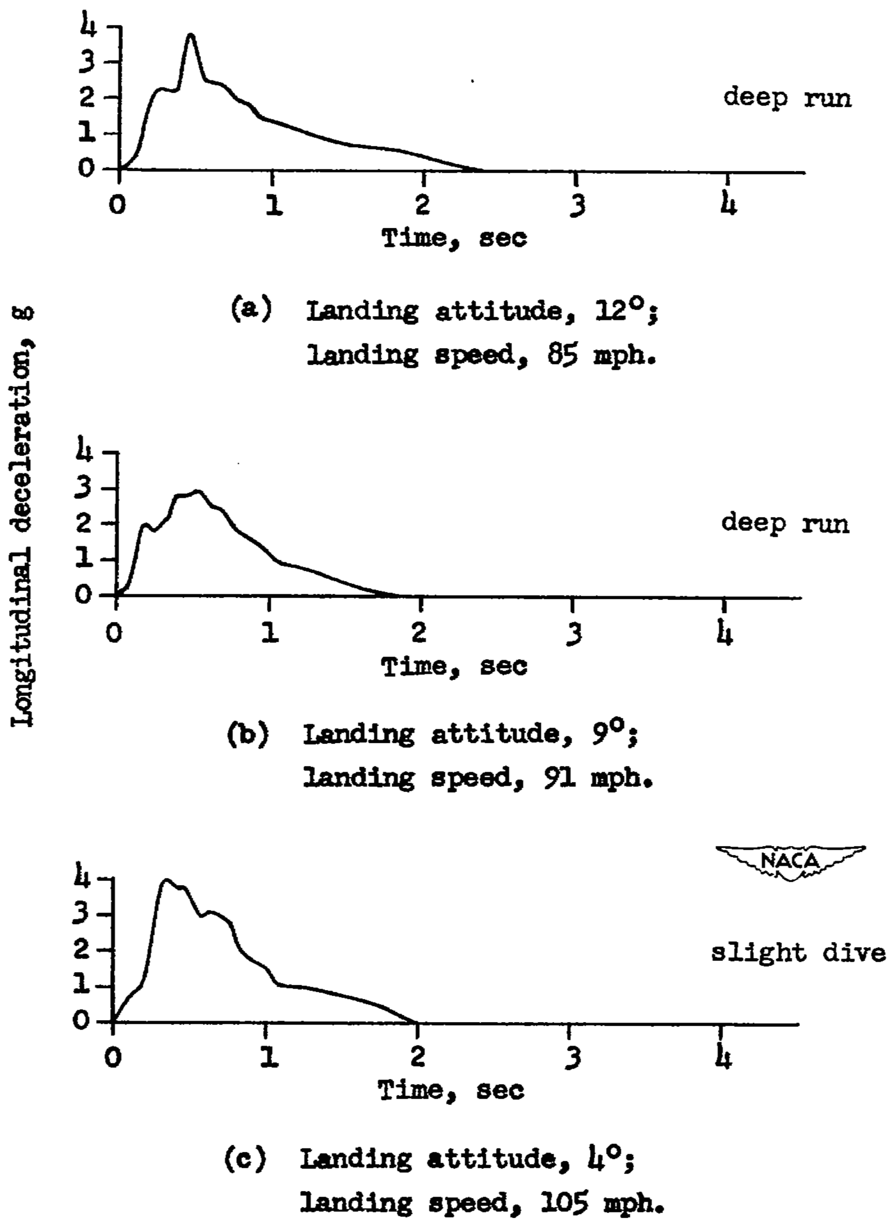
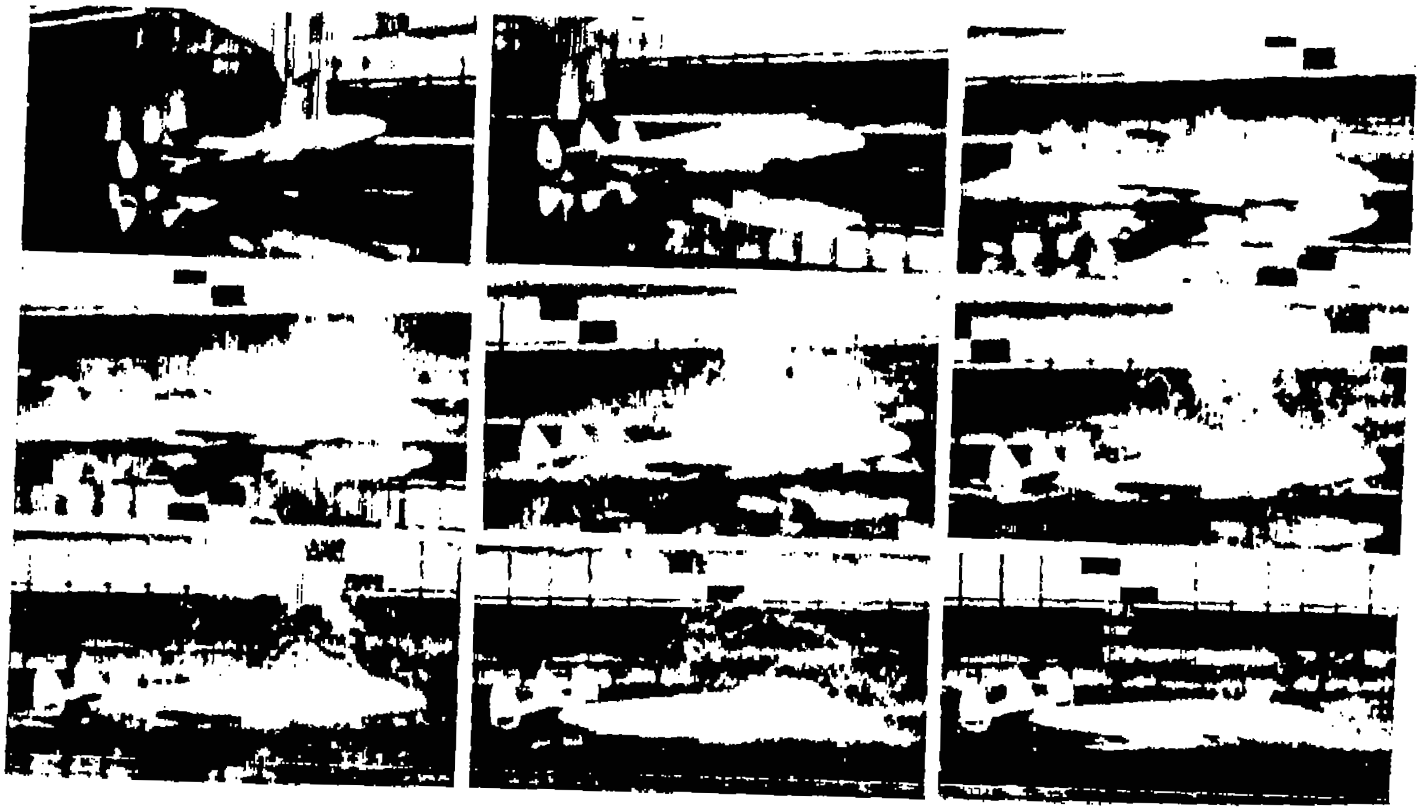


Figure 9.- Longitudinal decelerations with scale-strength bottom installed and flaps full down. All values are full scale.



(a) Landing attitude, 12°; smooth run.

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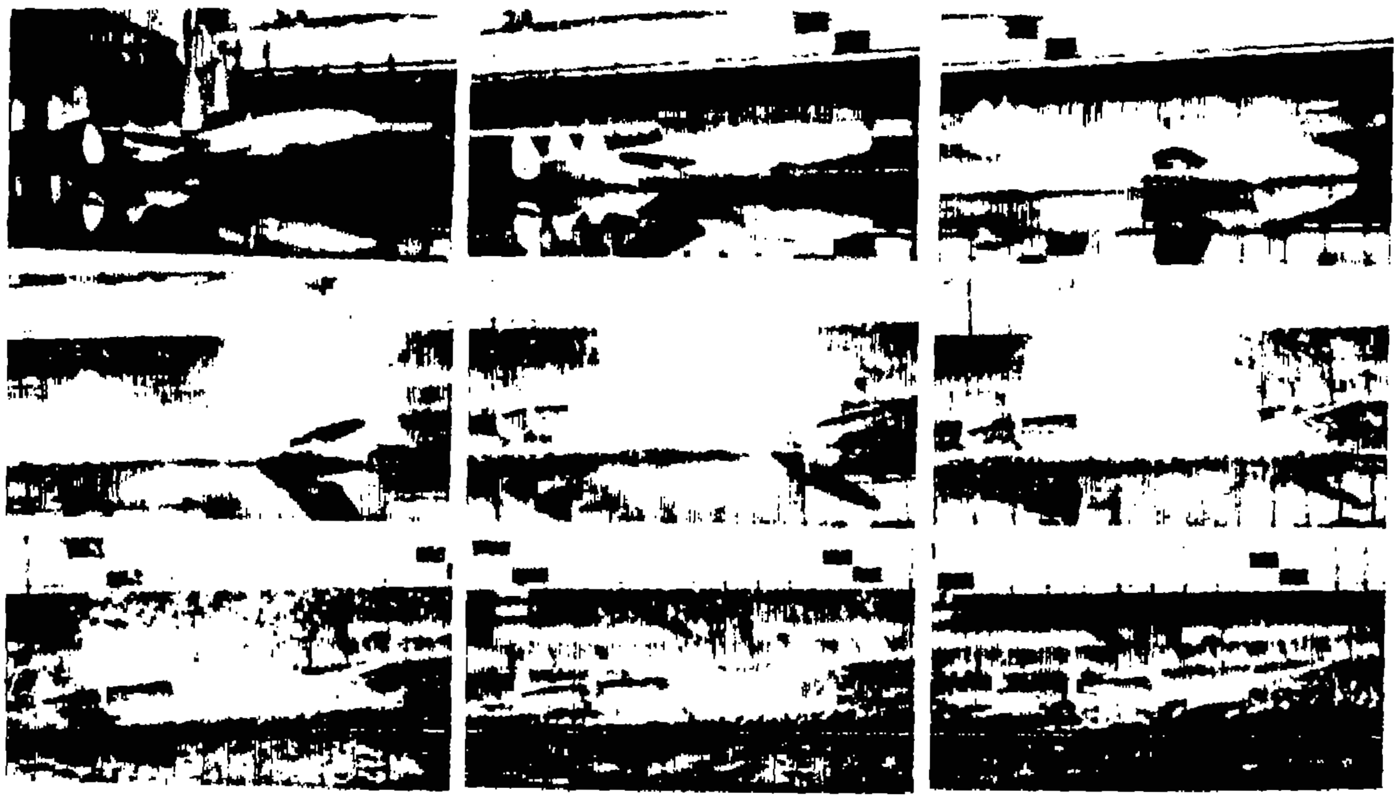
Figure 10.- Sequence photographs at 0.53-second intervals with scale-strength bottom installed and flaps full down. All values are full scale.



(b) Landing attitude, 9°; deep run.

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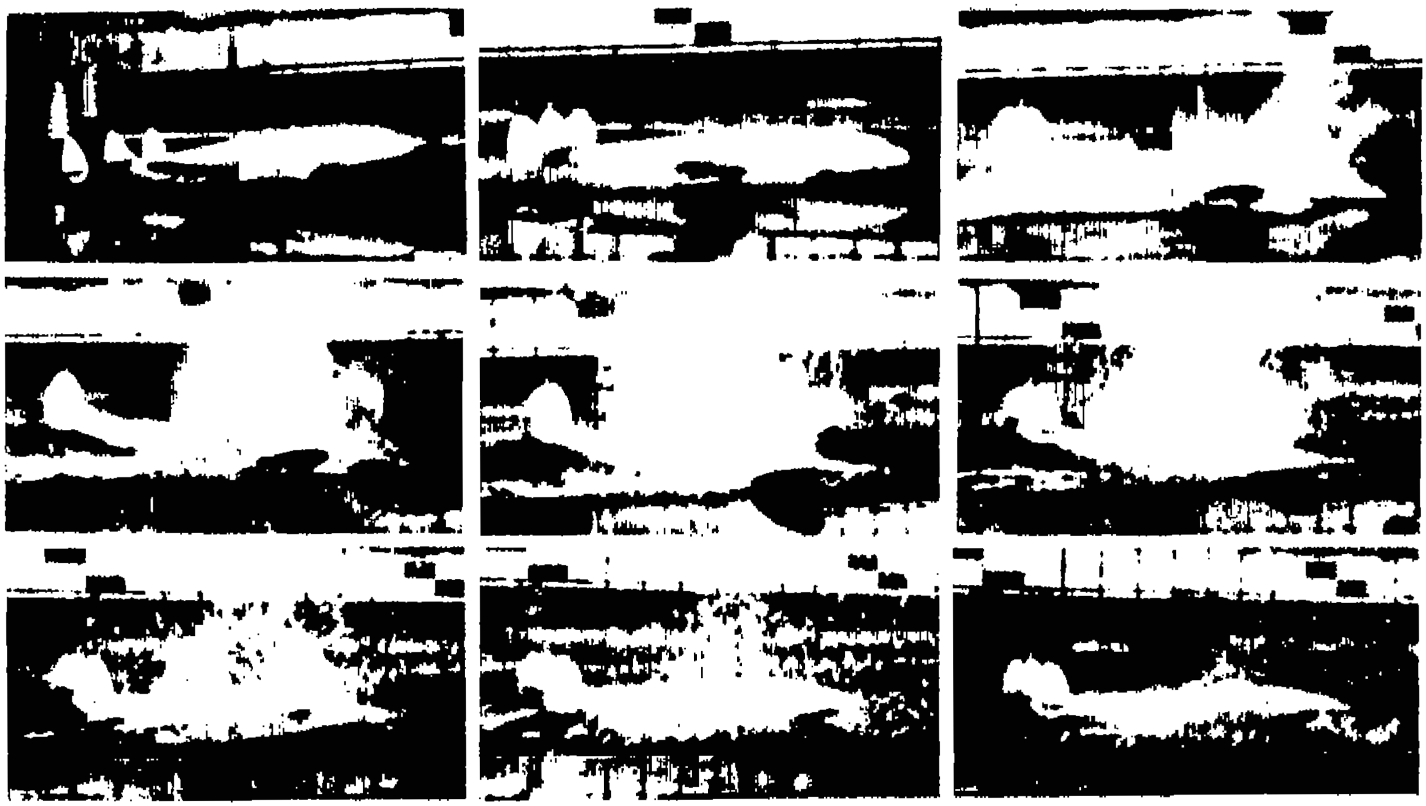
Figure 10.- Continued.



(c) Landing attitude, 4°; slight dive.

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Figure 10.- Concluded.